Maximizing the Efficiency of Condensing Boilers

Presented by

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Introduction

- Condensing boilers are commonly specified and installed in buildings today for efficiency benefit.

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  - System selection and setpoints are key to achieving rated efficiency!!!

Introduction

- The concepts and recommendations in this presentation are applicable to . . .

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  - Both new construction and existing buildings.
  - Both commercial and residential buildings.

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  - Both new construction and existing buildings.
  - Both commercial and residential buildings.

- $0 capital cost opportunities!!!

Introduction

- Learning Objective #1:
  - Be able to explain the impact of hot water temperature on condensing boiler efficiency.
  - Understanding efficiency ratings.
- Learning Objective #2:
  - Be able to explain the relationship between outdoor air temperature, heating load, and heating hot water temperature.

Introduction

- Learning Objective #3:
  - Be able to estimate hot water temperature reset setpoints that maximize condensing hours and satisfy heating loads.
- Learning Objective #4:
  - Be able to size terminal heating equipment for maximum condensing hours.

Introduction

- Learning Objective #5:
  - Describe operation of indirect DHW
  - Relate boiler HW temperature back to efficiency
  - Describe non-heating season impacts.

Condensing Boiler Basics

- Learning Objective #1:
  - Be able to explain the impact of hot water temperature on condensing boiler efficiency.
  - Understanding efficiency ratings.

Boiler Efficiency Ratings

- All boilers are not rated equally

Boiler Capacity (BTU/H)	Rating Method (%)
<300,000	**AFUE** – Annual Fuel Use Efficiency According to ASHRAE Standard 103
300,000 < 2,500,000	**Thermal Efficiency** According to ANSI Z21
>2,500,000	**Combustion Efficiency** According to ANSI Z21

Condensing Boilers - 101

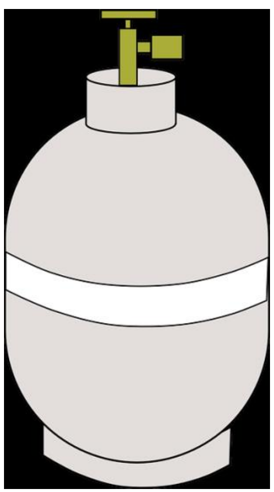
- Hot water, not steam
- Typically used with Nat Gas or Propane
- Up to 15% more efficient than a non-condensing boiler.
- The lower the return water temperature, the more efficient the boiler.

Condensing Boilers - 101

- What makes it “condensing” and why is this more efficient?

<u>Basic Hydrocarbon Combustion Equation:</u>

$$FUEL + O_2 \rightarrow STUFF + H_2O$$


+

→ STUFF +


Condensing Boilers - 101

Water vapor contains a LOT of energy.

- 1 LB of water requires:
  - 1 BTU to raise the temperature 1 °F
- 1 LB of water requires:
  - 970 BTUs to turn it into steam (with no temperature change)

Photo by Scott Akerman

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Condensing Boilers - 101

- Burning fuel makes water vapor (steam).
- This cannot be avoided.
- Turning that steam into water (CONDENSING) releases energy back into the process.

970 BTU / lb

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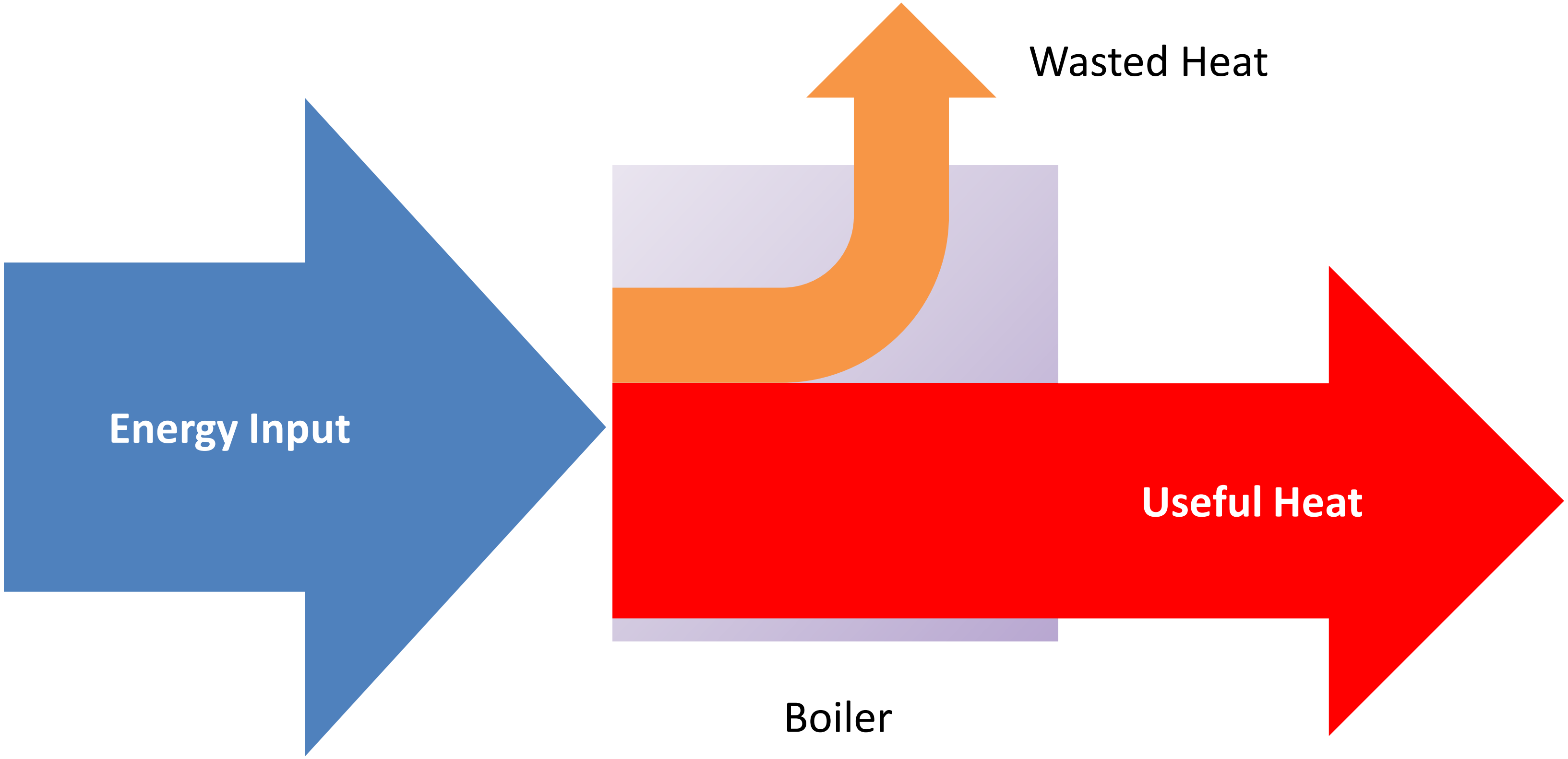
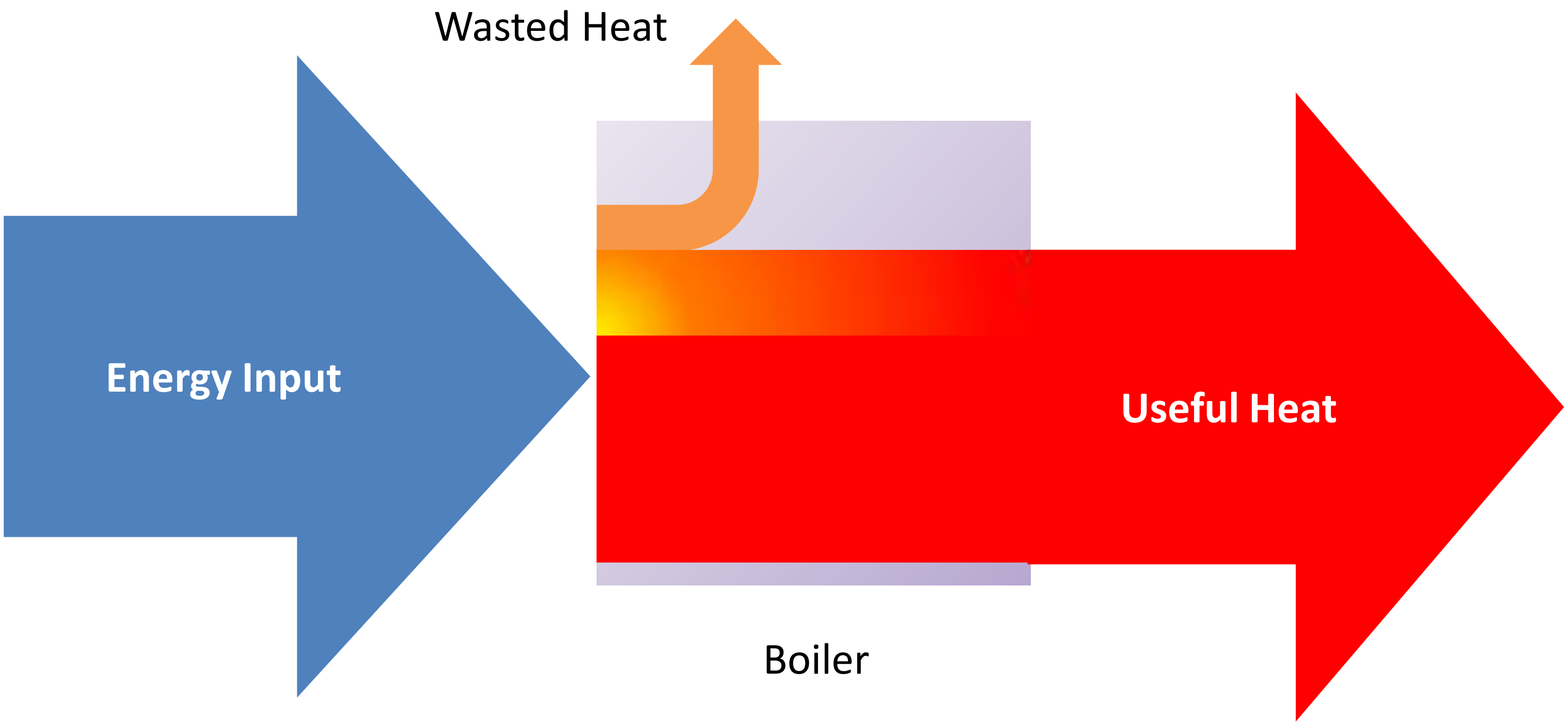
Condensing Boilers - 101

Non-condensing boiler thermal flowchart



Condensing Boilers - 101

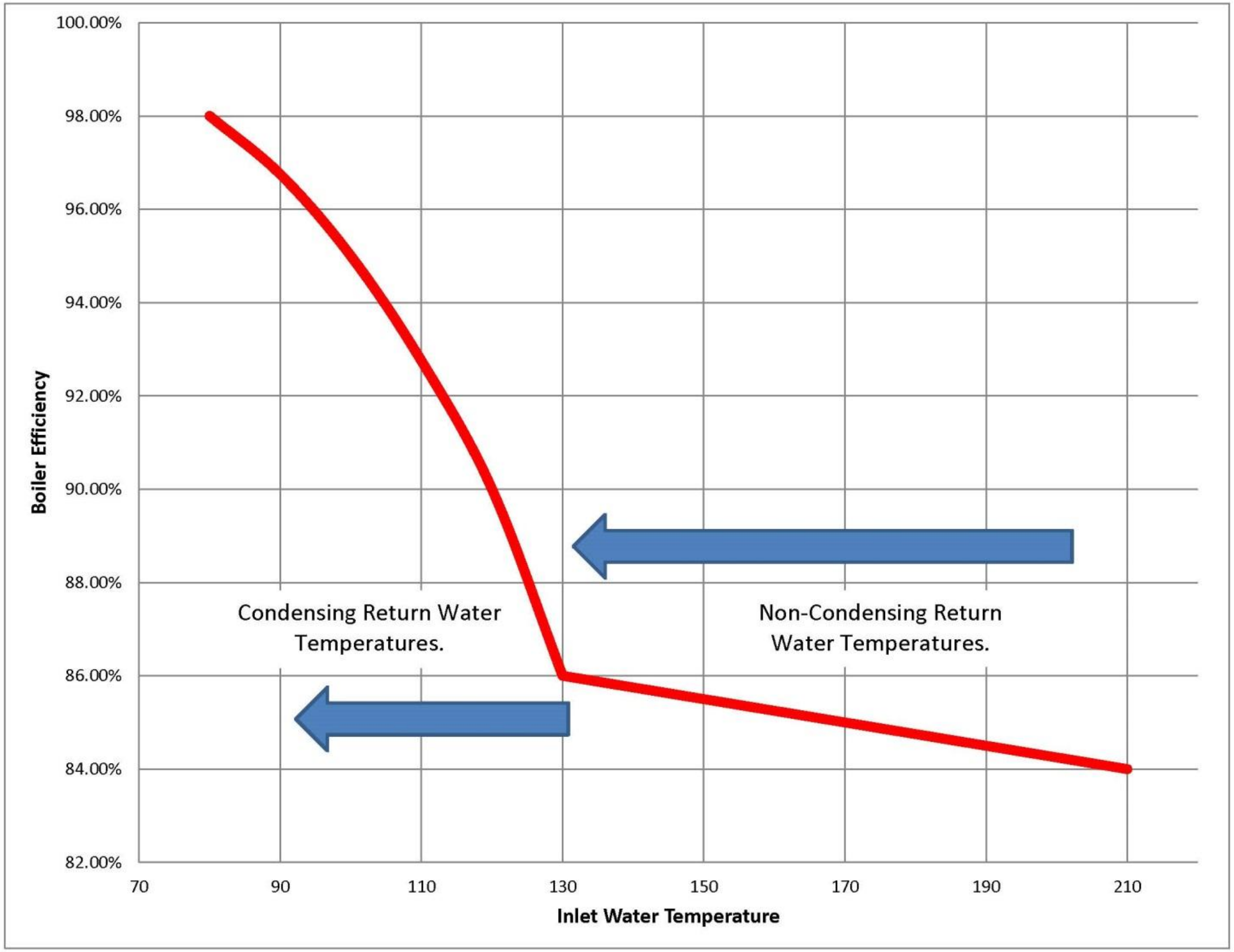
Condensing boiler thermal flowchart



Condensing Boilers - 101

- Vapor from natural gas combustion begins to condense at roughly 130 °F.
- It's NOT all or nothing.

Condensing Boilers - 101



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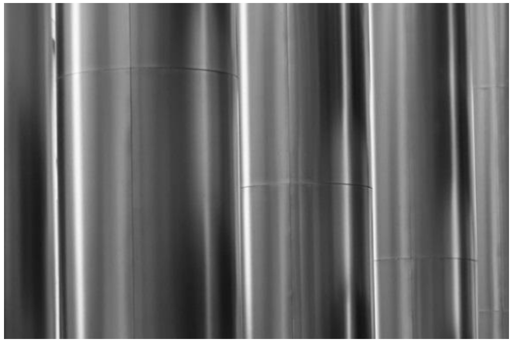
Condensing Boilers - 101

- <u>Notes on boiler construction</u>
- Different materials require different water treatment.
- Cast Aluminum, Stainless Steel, Possibly Cast Iron
- pH, Chlorides, alkalinity, cleanliness, etc.



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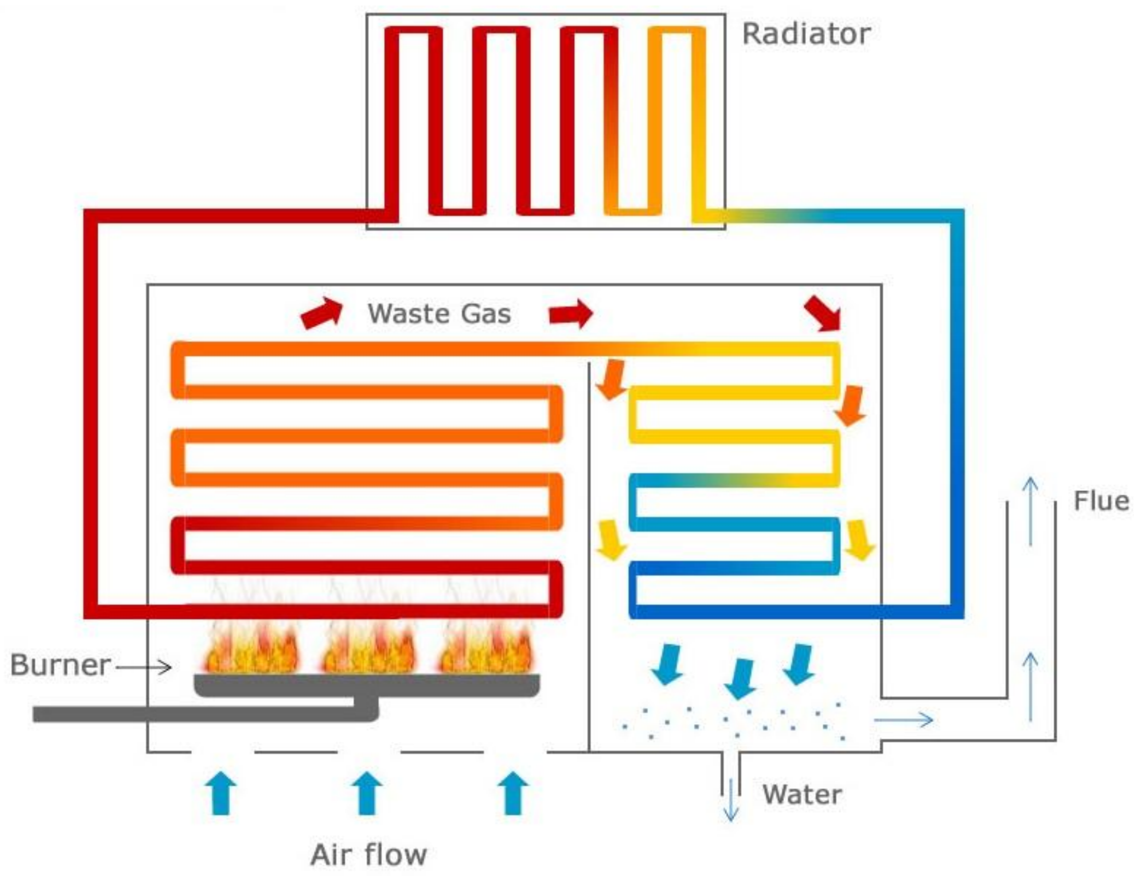
Condensing Boilers - 101

- "Partial" condensing boilers have stricter return water temperature limitations.



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Putting this Knowledge to Work

- Keep your return water temperatures **as low as you can for as long as you can**.
- How?
  - Make informed decisions about hot water temperature control
  - Make informed decisions about heat producing terminal devices.

Relationship Between OAT, Load, and HWT

- Learning Objective #2:
  - Be able to explain the relationship between outdoor air temperature, heating load, and heating hot water temperature.

Relationship Between OAT, Load, and HWT

- To keep return water "as low as you can for as long as you can," the hot water temperature (HWT) should be matched to the heating load.

- The heating load may be measured in terms of the outdoor air temperature (OAT), which may serve as a controlling parameter for HWT.

Relationship Between OAT, Load, and HWT

- Condensing boiler HWT control is based on the relationship between HWT, OAT, and the heating load.

Relationship Between OAT, Load, and HWT

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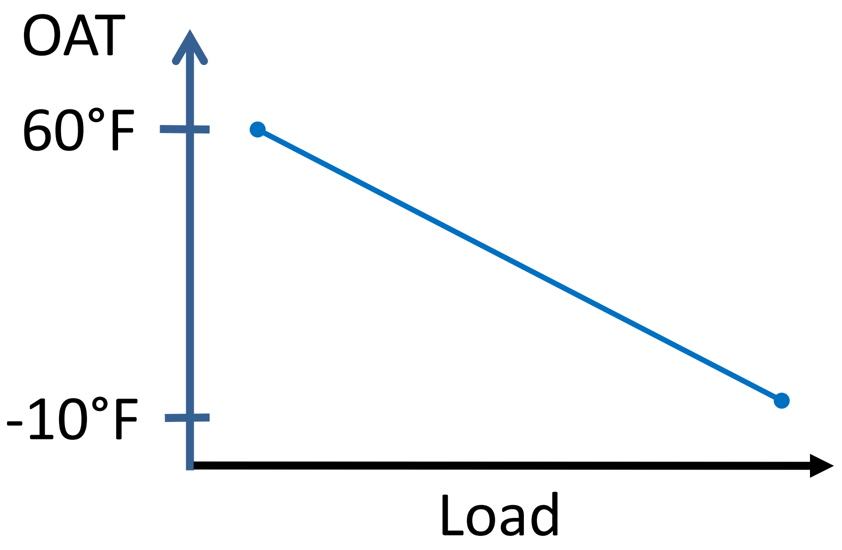
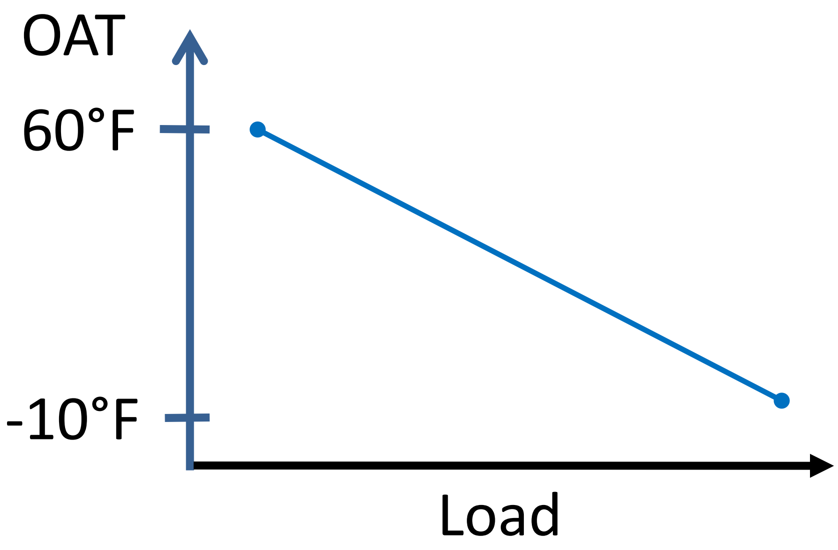


Relationship Between OAT, Load, and HWT

- Condensing boiler HWT control is based on the relationship between HWT, OAT, and the heating load.

- **Q = ΔT x k**



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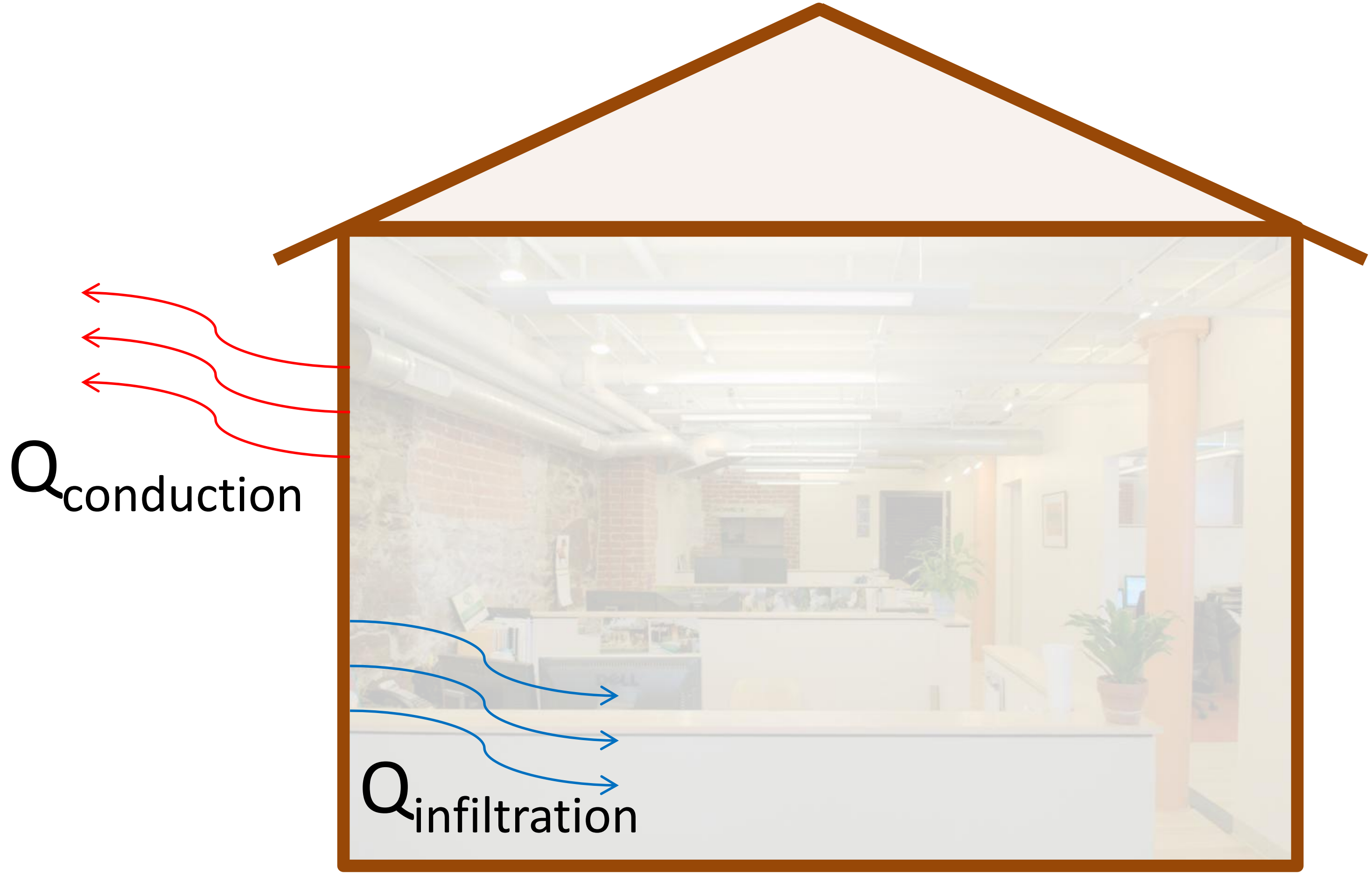
Relationship Between OAT, Load, and HWT



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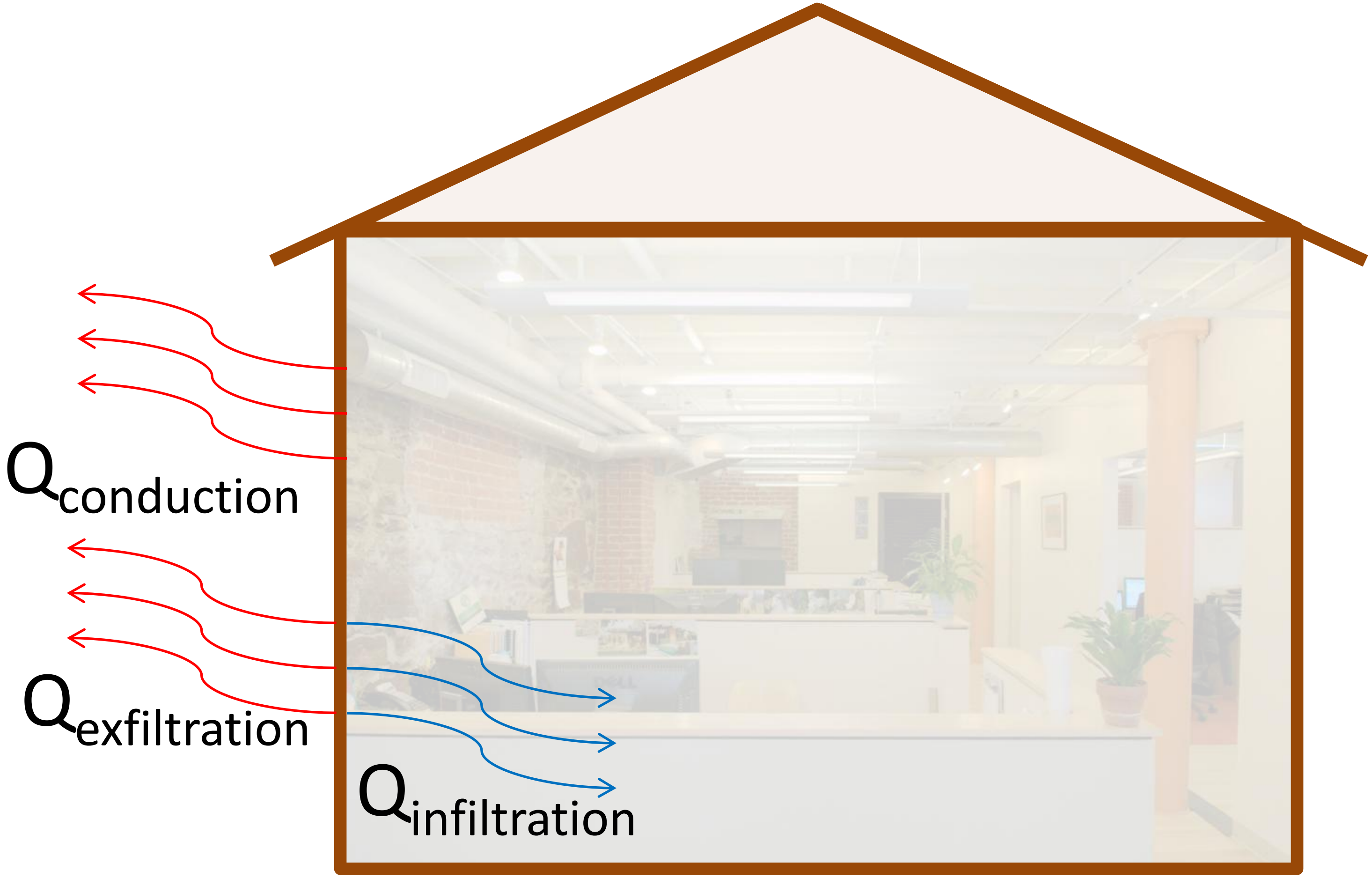

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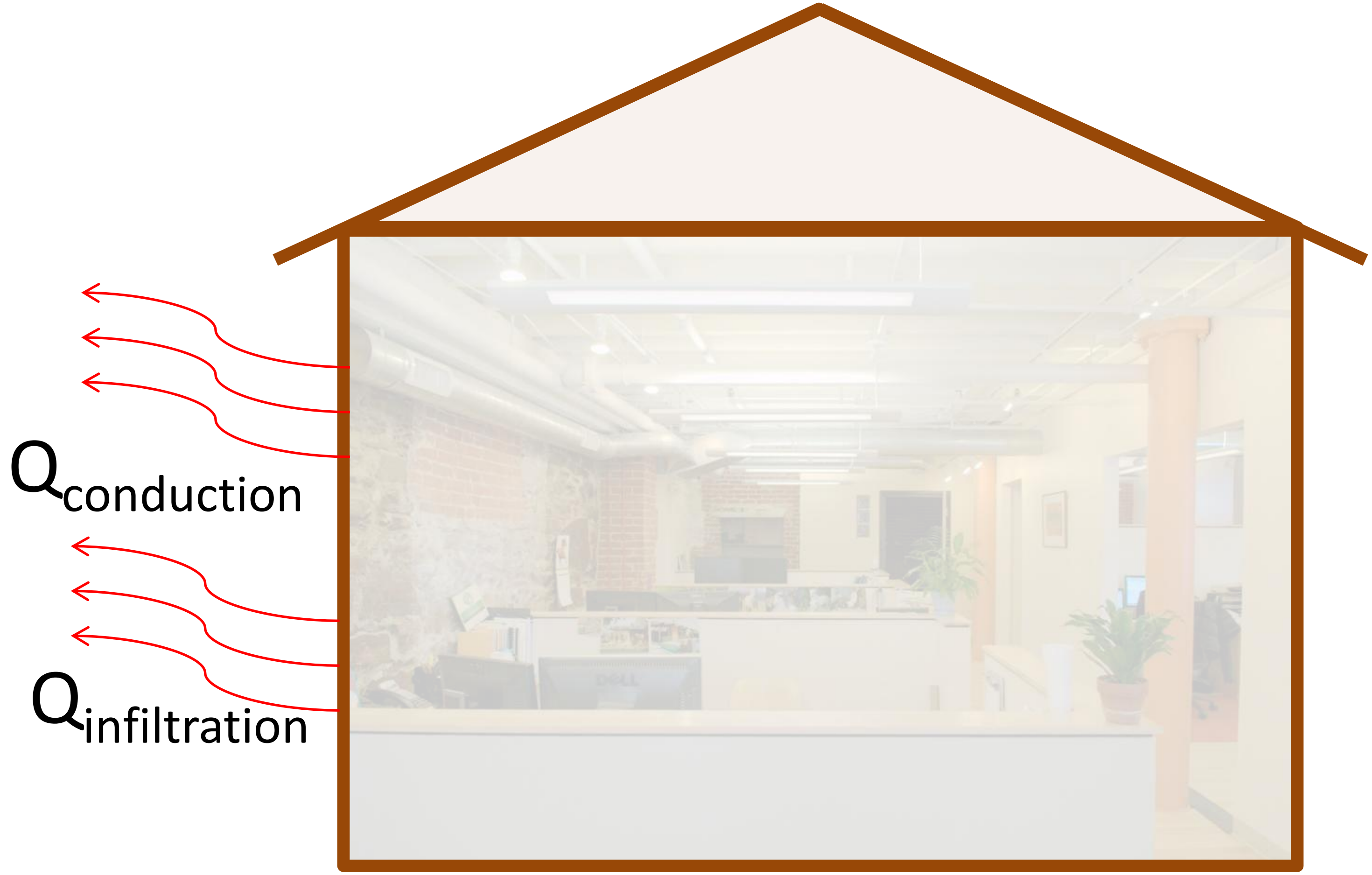

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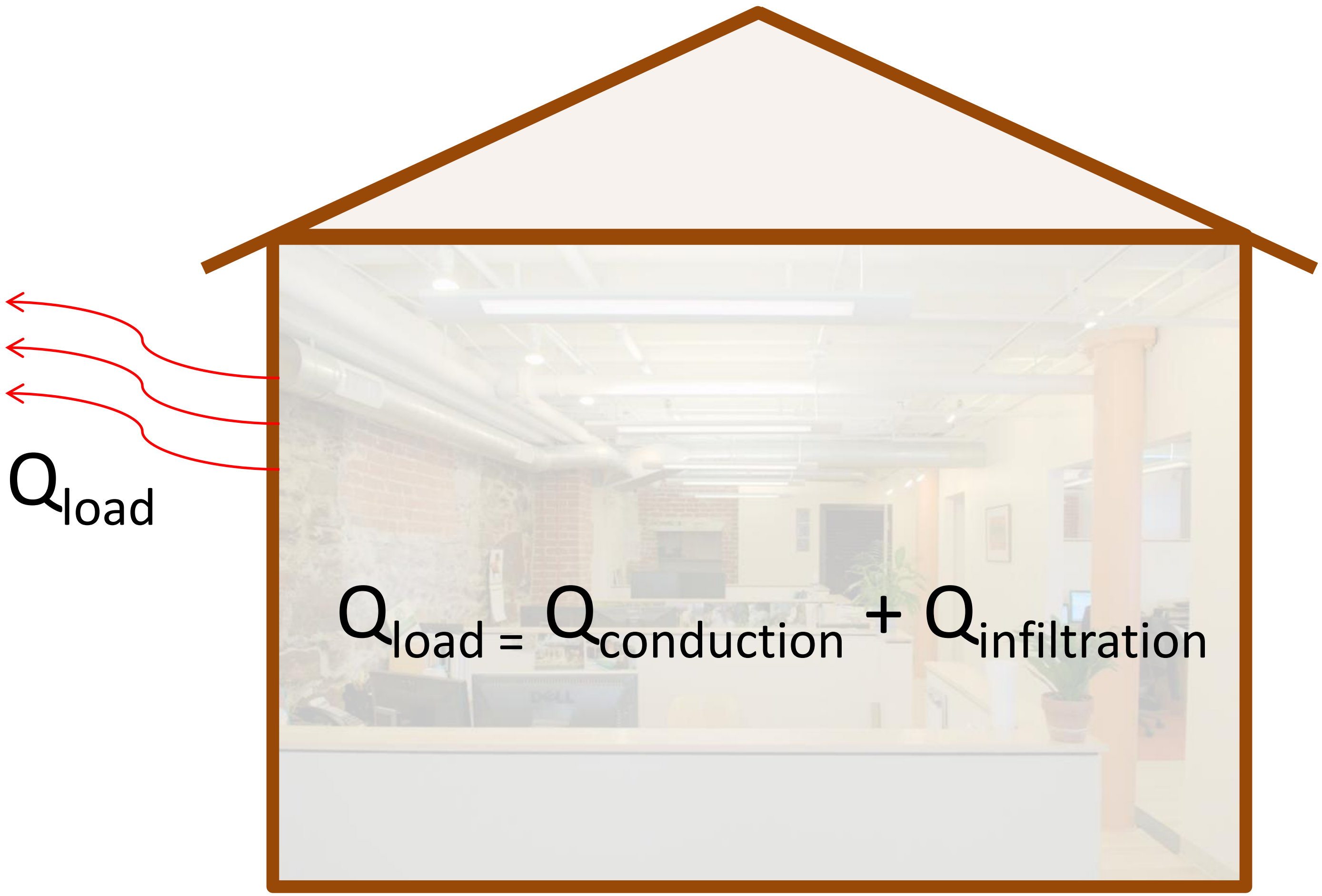
Relationship Between OAT, Load, and HWT



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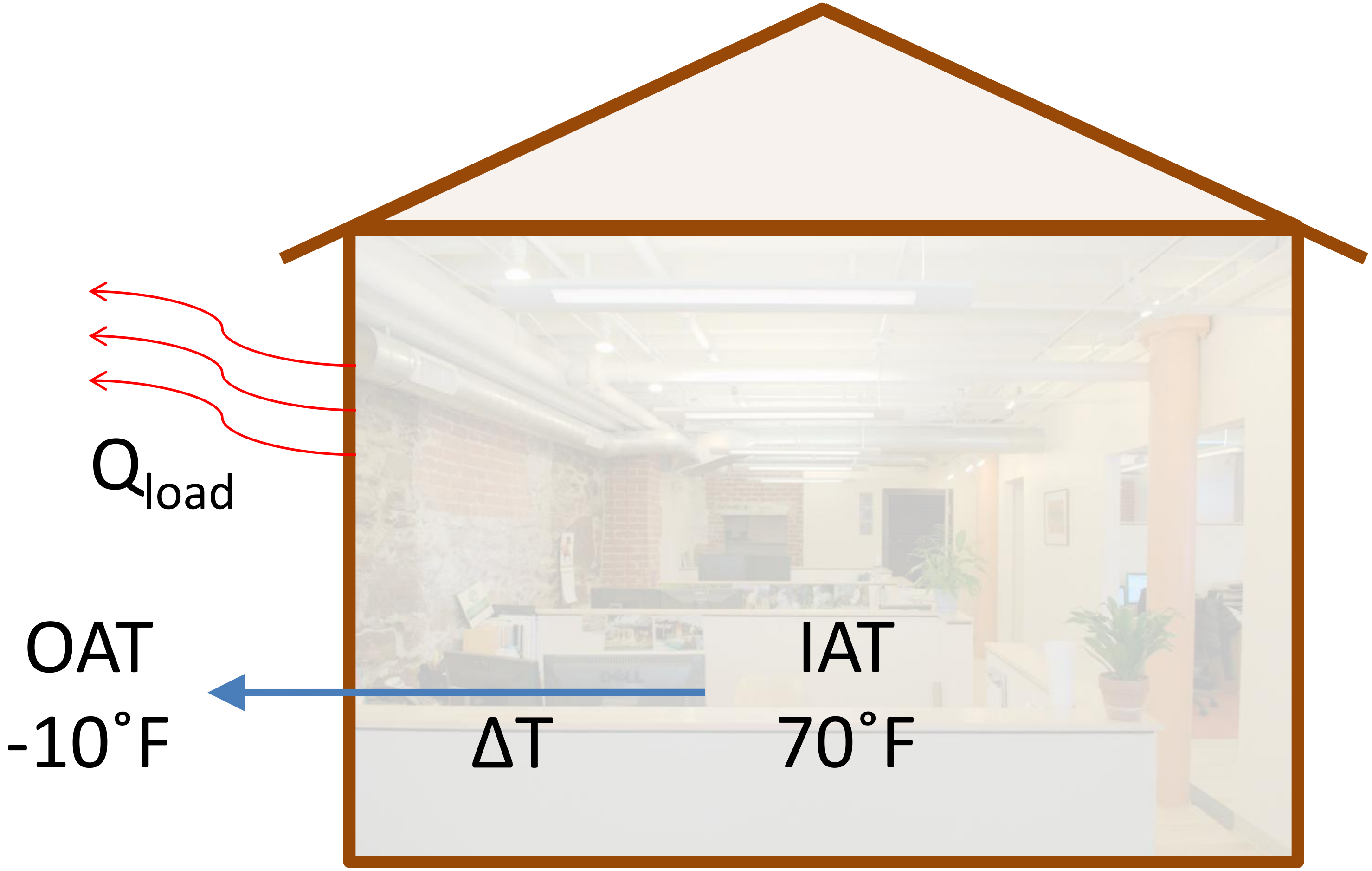

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{conduction} + Q_{infiltration}$

Relationship Between OAT, Load, and HWT

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$Q_{conduction} = (U \times A \times \Delta T)$

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{conduction} + Q_{infiltration}$

$Q_{conduction} = (U \times A \times \Delta T)$

$Q_{infiltration} = (1.08 \times CFM \times \Delta T)$

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Where:

- Q_{load} =
- U =
- A =
- ΔT=

- CFM =
- 1.08 =

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Relationship Between OAT, Load, and HWT

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Where:

Q_{load} = Heating Load (BTUH)
U =
A =
ΔT=

CFM =
1.08 =

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Where:

Q_{load} = Heating Load (BTUH)
U = Overall heat transfer coefficient (BTUH/ft^2- ˚ΔT)
A =
ΔT=

CFM =
1.08 =

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- Q_{load} = Heating Load (BTUH)
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- A = Envelope area (ft^2)
- ΔT= Difference between space temperature and outdoor air temperature
- CFM =
- 1.08 =

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Relationship Between OAT, Load, and HWT

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Where:

Q_{load} = Heating Load (BTUH)

U = Overall heat transfer coefficient (BTUH/ft^2- ˚ΔT)

A = Envelope area (ft^2)

ΔT= Difference between space temperature and outdoor air temperature

CFM = Infiltration airflow (ft^3/minute)

1.08 =

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Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{conduction} + Q_{infiltration}$
$Q_{conduction} = (U \times A \times \Delta T)$
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Where:

Q_{load} = Heating Load (BTUH)
U = Overall heat transfer coefficient (BTUH/ft^2- ˚ΔT)
A = Envelope area (ft^2)
ΔT= Difference between space temperature and outdoor air temperature
CFM = Infiltration airflow (ft^3/minute)
1.08 = Air heat capacitance and unit conversion (BTUH-min/ft^3-hr-°F)

Relationship Between OAT, Load, and HWT

$Q_{conduction} = (U \times A \times \Delta T)$

$Q_{infiltration} = (1.08 \times CFM \times \Delta T)$

Relationship Between OAT, Load, and HWT

$Q_{conduction} = (U \times A \times \Delta T)$

$Q_{infiltration} = (1.08 \times CFM \times \Delta T)$

$Q_{load} = (U \times A \times \Delta T) + (1.08 \times CFM \times \Delta T)$

Relationship Between OAT, Load, and HWT

$Q_{conduction} = (U \times A \times \Delta T)$

$Q_{infiltration} = (1.08 \times CFM \times \Delta T)$

$Q_{load} = (U \times A \times \Delta T) + (1.08 \times CFM \times \Delta T)$

$Q_{load} = \Delta T[(U \times A) + (1.08 \times CFM)]$

Relationship Between OAT, Load, and HWT

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$Q_{load} = (U \times A \times \Delta T) + (1.08 \times CFM \times \Delta T)$

$Q_{load} = \Delta T[(U \times A) + (1.08 \times CFM)]$

$$Q_{load} = \Delta T \times k$$

Relationship Between OAT, Load, and HWT

$Q_{load} = \Delta T \times k$

Where:

k = constant

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{terminal\_heat} + Q_{heat\_gain}$

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{terminal\_heat} + Q_{heat\_gain}$

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{terminal\_heat}$

$Q = \Delta T \times k$

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{terminal\_heat}$

$Q = \Delta T \times k$

$k = Q / \Delta T$

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{terminal\_heat}$

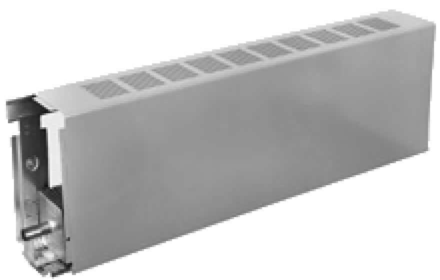
$Q = \Delta T \times k$

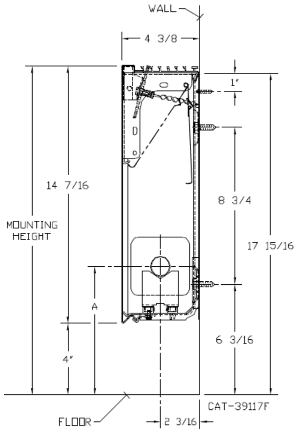
$k = Q / \Delta T$

- Solve for k, using load on design day

Relationship Between OAT, Load, and HWT

Tube Size	Catalog Designation	Fin Size	Fin per ft.	Fin Thickness	Encl. Depth and Height (in.)	Tiers and Centers (in.)	Mounting Height (in.)	Steam 215°F Factor 1.00	Hot Water (Avg.) 200°F Factor 0.86	190°F 0.78	180°F 0.69	170°F 0.61	160°F 0.53	150°F 0.45
3/4"	C3/4-33	3-1/4" SQ.	32	0.020"	14A	1	18-7/16	1050	900	820	720	640	560	470





Relationship Between OAT, Load, and HWT

Catalog Designation		Steam 215°F Factor 1.00	Hot Water (Avg.)					
			200°F	190°F	180°F	170°F	160°F	150°F
			Factor					
			0.86	0.78	0.69	0.61	0.53	0.45
C3/4-33	BTUH/LF	1050	900	820	720	640	560	470

Relationship Between OAT, Load, and HWT

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C3/4-33	BTUH	10,500	9,000	8,200	7,200	6,400	5,600	4,700

Relationship Between OAT, Load, and HWT

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C3/4-33	BTUH	10,500	9,000	8,200	7,200	6,400	5,600	4,700

Relationship Between OAT, Load, and HWT

$Q_{load} = Q_{terminal\_heat}$

$Q = \Delta T \times k$

$k = Q / \Delta T$

$K = (6{,}400\ BTUH) / (70°F – (-10°F))$

$K = 80\ [BTUH/\Delta°F]$

Relationship Between OAT, Load, and HWT

$Q = \Delta T \times k$

Use value of k to calculate Q at 60°F OAT.

Relationship Between OAT, Load, and HWT

$Q = \Delta T \times k$

Use value of k to calculate Q at 60°F OAT.

$Q = (70°F – (60°F)) \times (80\ BTUH/\Delta °F)$

$Q = 800\ BTUH$

Relationship Between OAT, Load, and HWT

Q = 800 BTUH

Catalog Designation		Steam 215°F Factor 1.00	Hot Water (Avg.)					
			200°F	190°F	180°F	170°F	160°F	150°F
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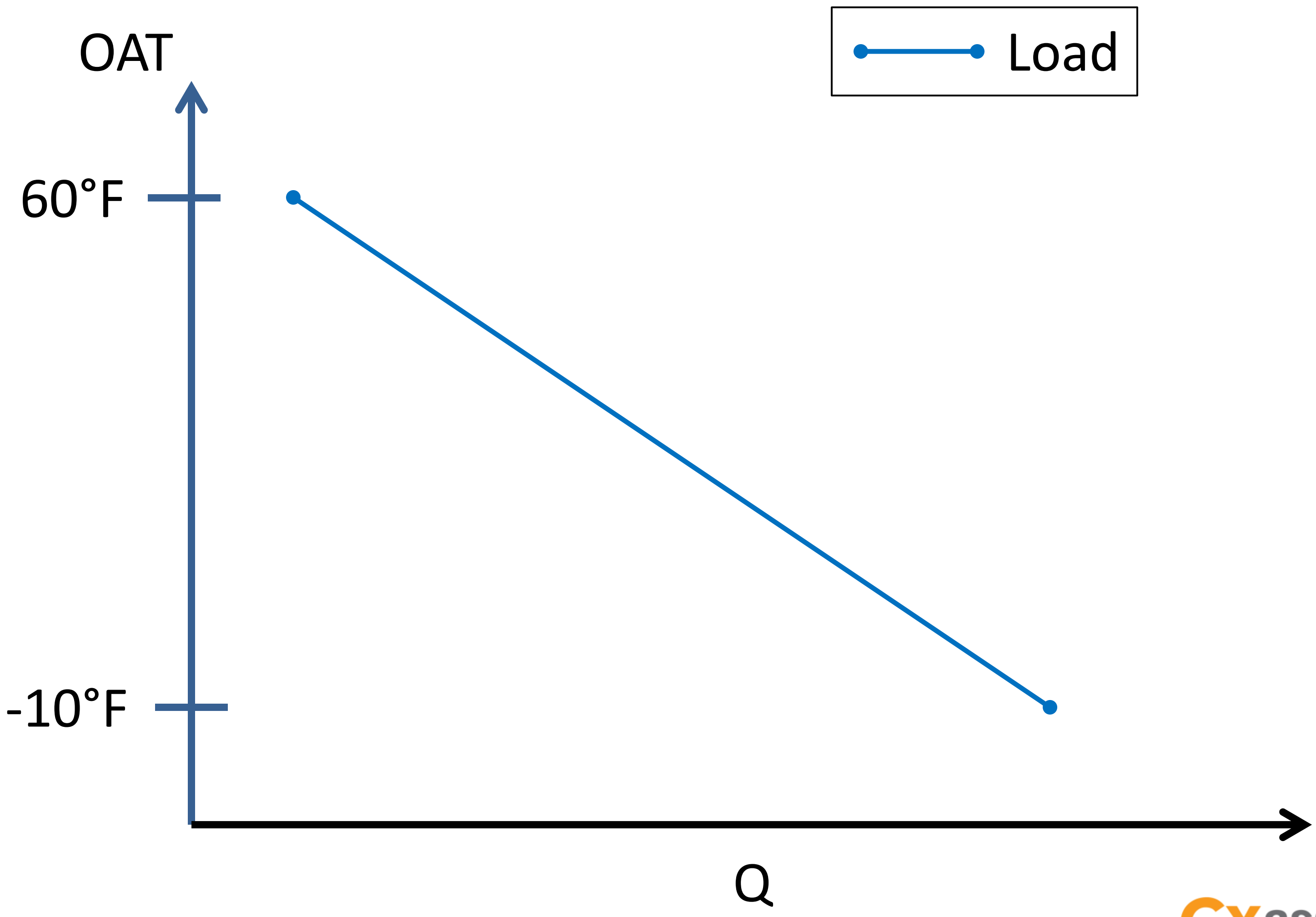
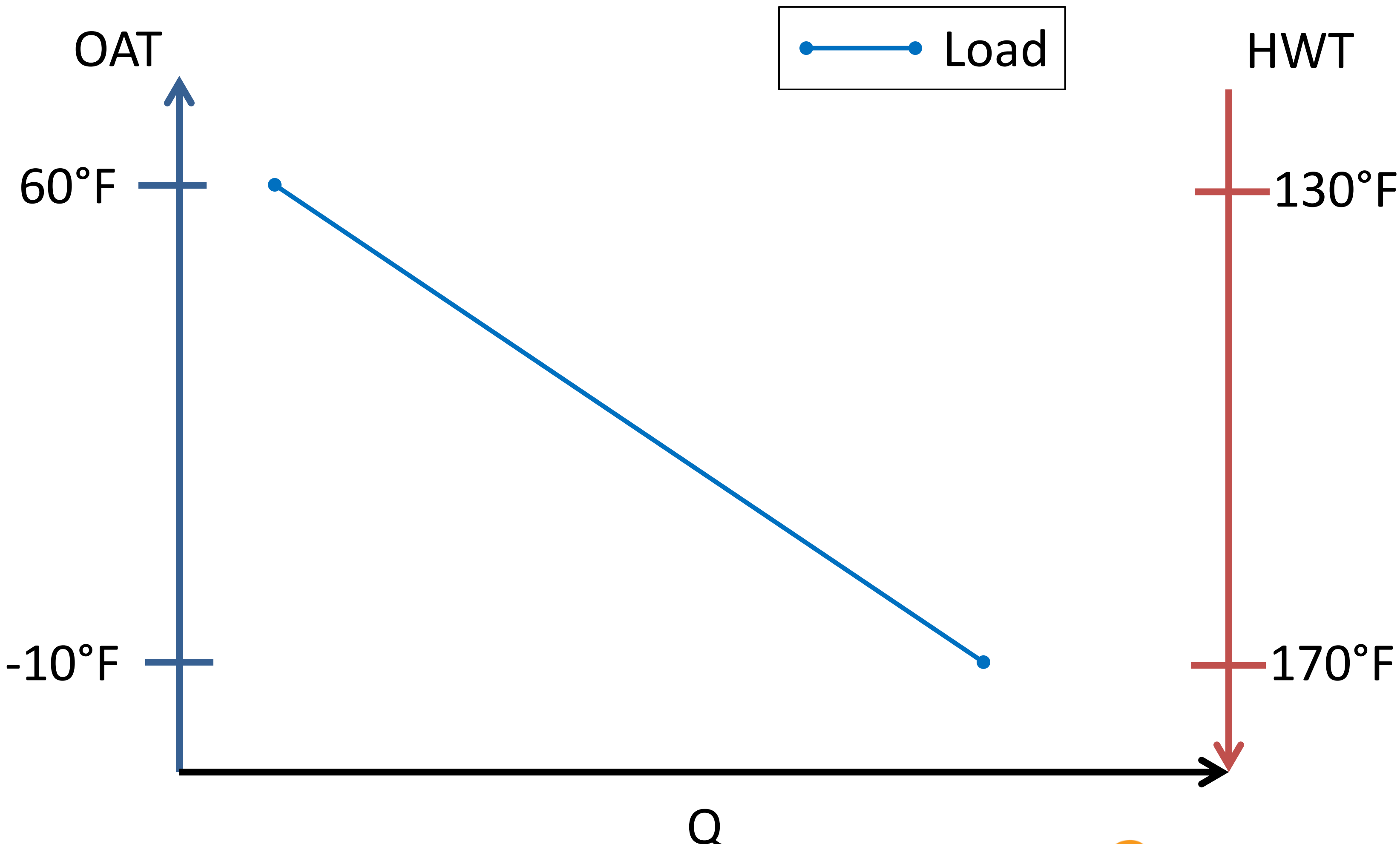
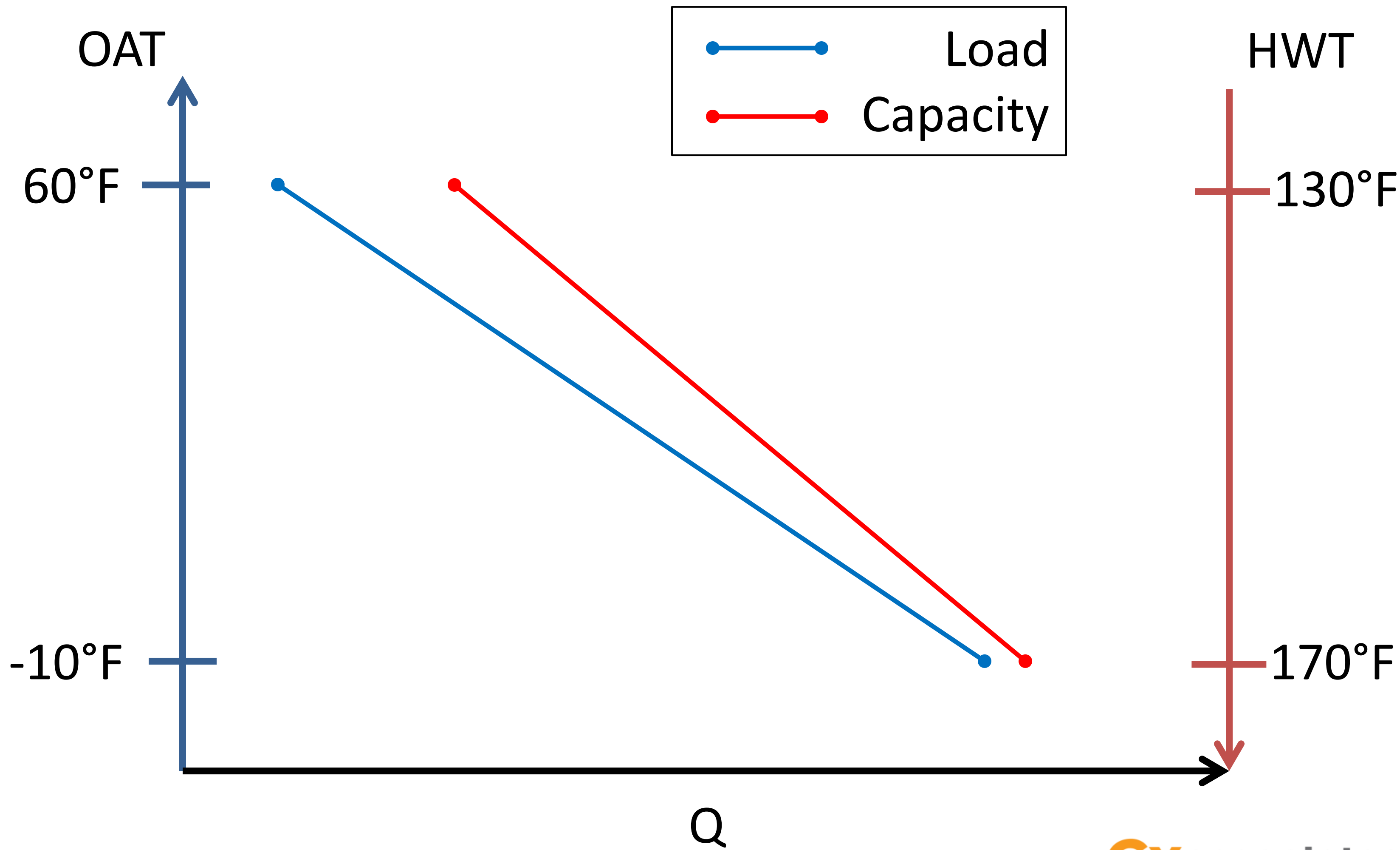
Relationship Between OAT, Load, and HWT



Relationship Between OAT, Load, and HWT



Relationship Between OAT, Load, and HWT



Controls – Determining the Right Reset Schedule

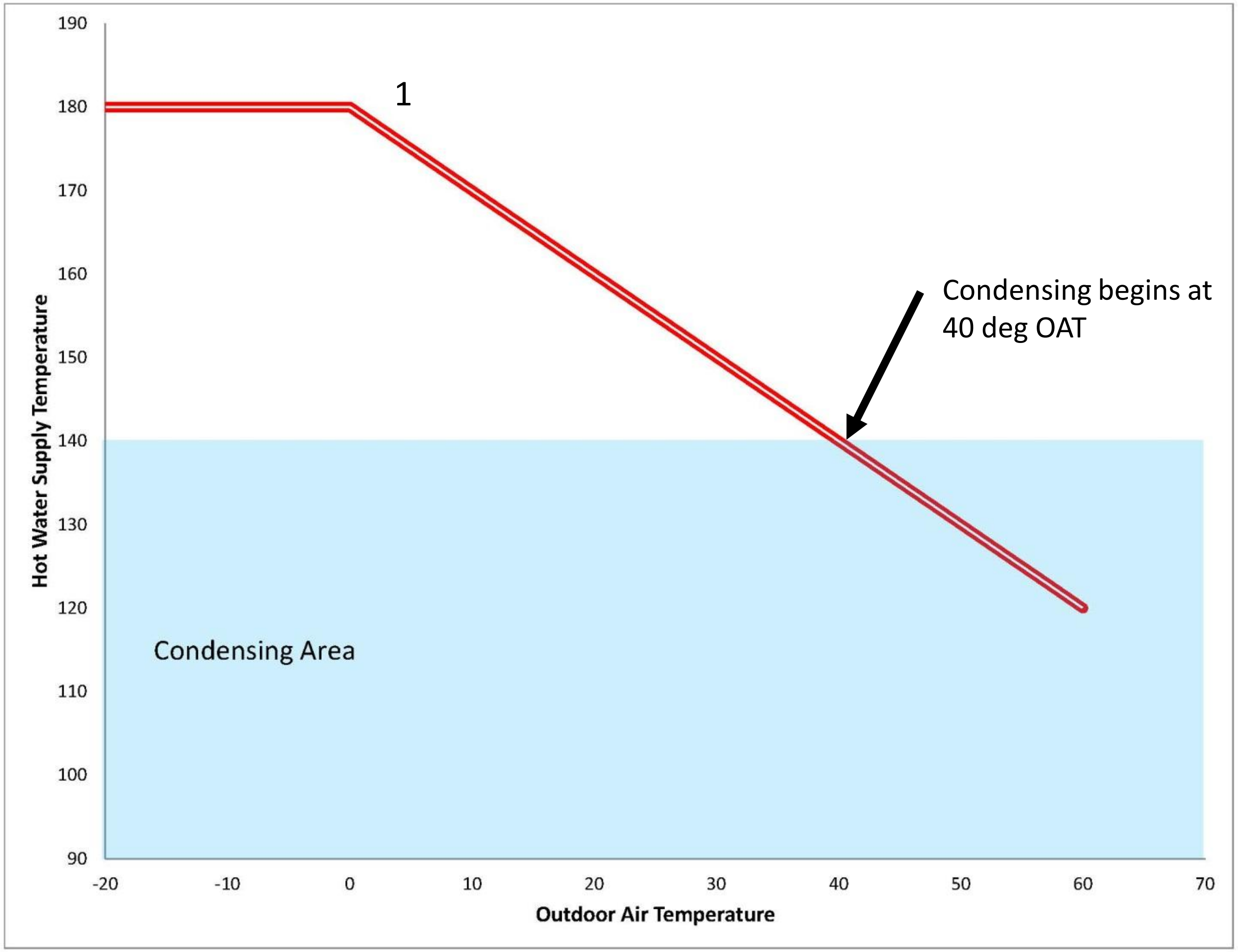
- <u>Learning Objective #3</u>:
  - Be able to estimate hot water temperature reset setpoints that maximize condensing hours and satisfy heating loads.

Determining the Right Reset Schedule

- What is a “reset schedule”?
  - Means of controlling the Hot Water Supply Temp (HWST) based on the Outdoor Air Temp (OAT)
- Example of Typical Reset Schedule

OAT		HWST	
OAT_{MIN}	0	$HWST_{MAX}$	180
OAT_{MAX}	60	$HWST_{MIN}$	120

Determining the Right Reset Schedule



1 – Initial Reset Schedule

Determining the Right Reset Schedule

- Burlington VT has 6,995 hours per year below 65 degrees (TMY3).
- Previous reset schedule example only results in 3,650 hours per year of condensing in Burlington, VT. (52% of possible hours)
- Let’s do better….

Determining the Right Reset Schedule

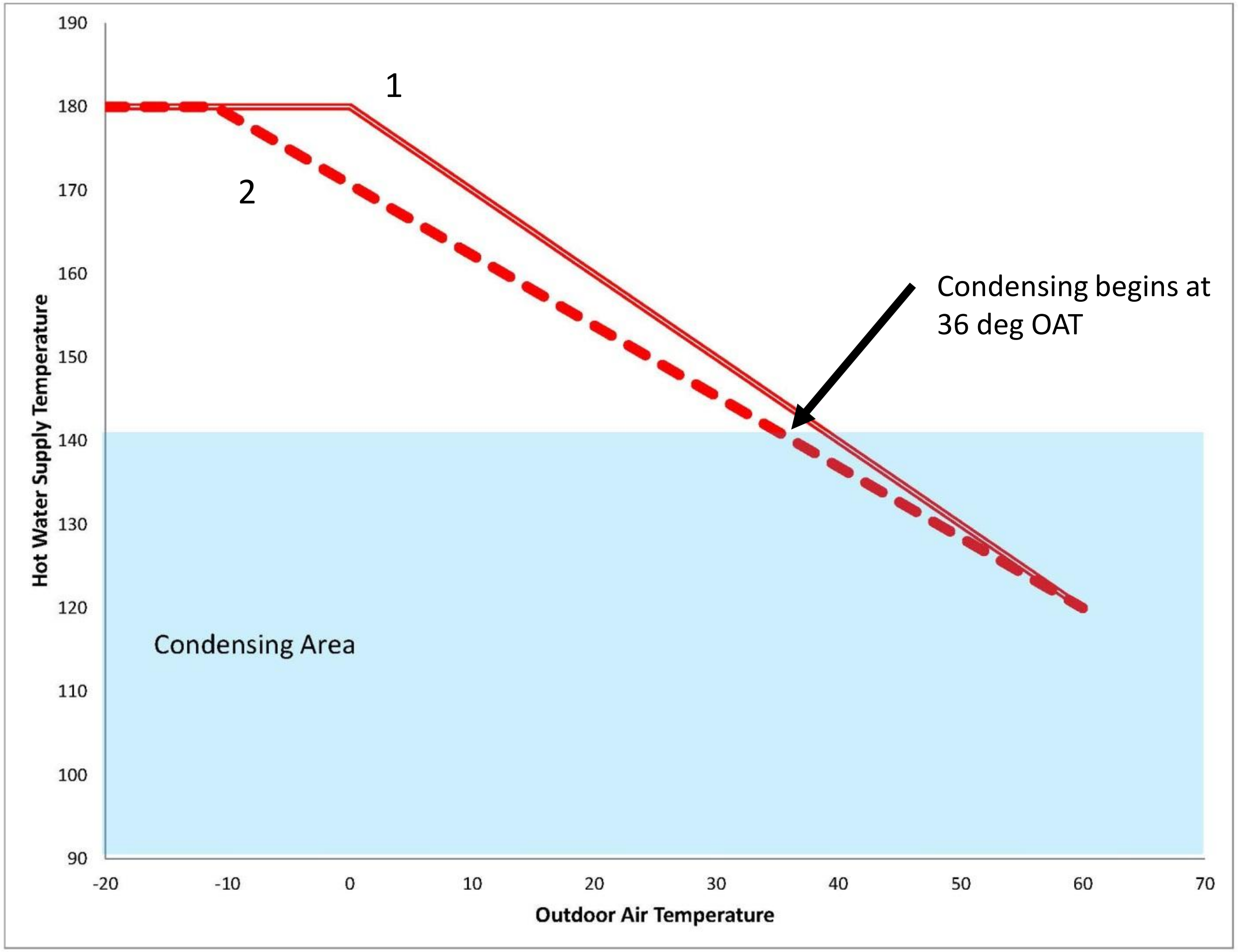
- Initial reset schedule used 0 deg OAT as a design condition – maximum HWST.

OAT		HWST	
OAT_{MIN}	0	$HWST_{MAX}$	180
OAT_{MAX}	60	$HWST_{MIN}$	120

- Revise to reflect the ***actual*** OAT design condition

OAT		HWST	
OAT_{MIN}	*-11*	$HWST_{MAX}$	180
OAT_{MAX}	60	$HWST_{MIN}$	120

Determining the Right Reset Schedule



1 – Initial Reset Schedule
2 – MIN OAT from 0 to -11

Determining the Right Reset Schedule

- Changing the OAT design condition increases condensing hours from 3,650 to 4,160 per year
- 59% of possible hours

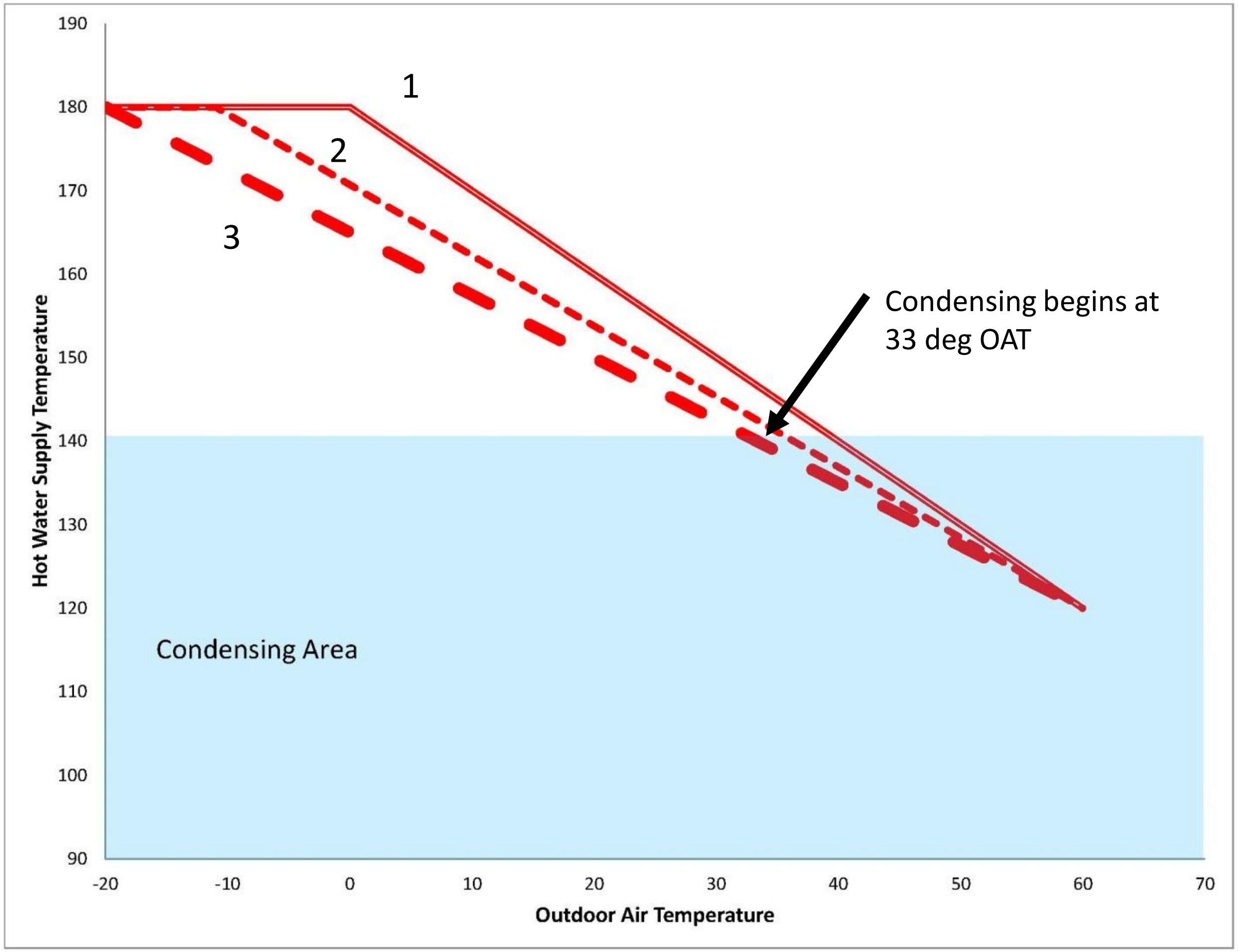
OAT		HWST	
OAT_{MIN}	*-11*	$HWST_{MAX}$	180
OAT_{MAX}	60	$HWST_{MIN}$	120

Determining the Right Reset Schedule

- It gets colder than -11. -20 is more likely the actual condition for which the system was designed.
- Increases condensing hours from 3,650 to 4,580 per year.
- 66% of possible hours

OAT		HWST	
OAT_{MIN}	*-20*	$HWST_{MAX}$	180
OAT_{MAX}	60	$HWST_{MIN}$	120

Determining the Right Reset Schedule



1 – Initial Reset Schedule
2 – MIN OAT from 0 to -11
3 – MIN OAT from -11 to -20

Determining the Right Reset Schedule

- Went from 52% to 66% of possible hours by simply changing the MIN OAT to the actual design OAT.

Determining the Right Reset Schedule

- Went from 52% to 66% of possible hours by simply changing the MAX OAT to the actual design OAT.
- Next step – are 120 HWST and 60 OAT right?
- 120 HWST results in a return temp of between 100.
  - Most condensing boilers will accept an 80 degree or lower entering water temp.
  - Use 100 deg F HWST.

Determining the Right Reset Schedule

- Next step – are 120 HWST and 60 OAT right?
- 120 HWST results in a return temp of between 100 and 110.
  - Most condensing boilers will accept an 80 degree entering water temp.
  - Use 100 deg F HWST.
- What about 60 OAT?

Determining the Right Reset Schedule

- Example – 10 ft x 14 ft office with an 8 ft ceiling.
- Heating Load = 2,100 BTUH
  - 70 deg indoor, -20 deg outdoor
- Designed with 4 ft of active finned tube radiation.
- At design conditions we need 525 BTUH/LF

Determining the Right Reset Schedule

- Finned tube output needed - 525 BTUH/LF

AWT	180	170	160	150	140	130	120	110	100	90
BTUH/LF	652	576	501	425	378	312	246	189	142	104

- 170 deg AWT satisfied the load.
- This selection satisfies design heat loss conditions using 180 deg HWST.

Determining the Right Reset Schedule

- Earlier we decided to use a minimum 100 deg HWST.

AWT	180	170	160	150	140	130	120	110	100	90
BTUH/LF	652	576	501	425	378	312	246	189	142	104

- Finned tube output at 100 deg HWST or 90 deg AWT = 104 BTUH/LF
- 4 Feet ⟺ 416 BTUH capacity.

Determining the Right Reset Schedule

- Earlier we decided to use a minimum 100 deg HWST.

AWT	180	170	160	150	140	130	120	110	100	90
BTUH/LF	652	576	501	425	378	312	246	189	142	104

- Finned tube output at 100 deg HWST or 90 deg AWT = 104 BTUH/LF
- 4 Feet ⟺ 416 BTUH capacity.
- ***At what OAT does the output match the load?***

Determining the Right Reset Schedule

- 416 BTUH capacity at 90 deg AWT
- Earlier we concluded $Q = k \times \Delta T$
- Q = 2,100 BTUH
- ΔT = 70 (indoor temp) – (-20 outdoor temp) = 90 ^{o}F
- k = 23.33

Determining the Right Reset Schedule

- 416 BTUH capacity at 90 deg AWT
- Earlier we concluded $Q = k \times \Delta T$
- Q = 2,100 BTUH
- $\Delta T = 70 - (-20) = 90$
- k = 23.33
- Use this k to find ΔT based on matching 416 BTUH capacity to heating load.

Determining the Right Reset Schedule

- $Q = k \times \Delta T$
- Q = 416 BTUH and k = 23.33
- 416 / 23.33 = 18 deg ΔT
- 65 OAT – 18 deg ΔT = 47 deg OAT

We're assuming that at 65 degrees OAT, the heating load to maintain 70 deg IAT is exactly zero.

Determining the Right Reset Schedule

- Q = k x ΔT
- Q = 416 BTUH and k = 23.33
- 416 / 23.33 = 18 deg
- 65 – 18 = 47 deg OAT

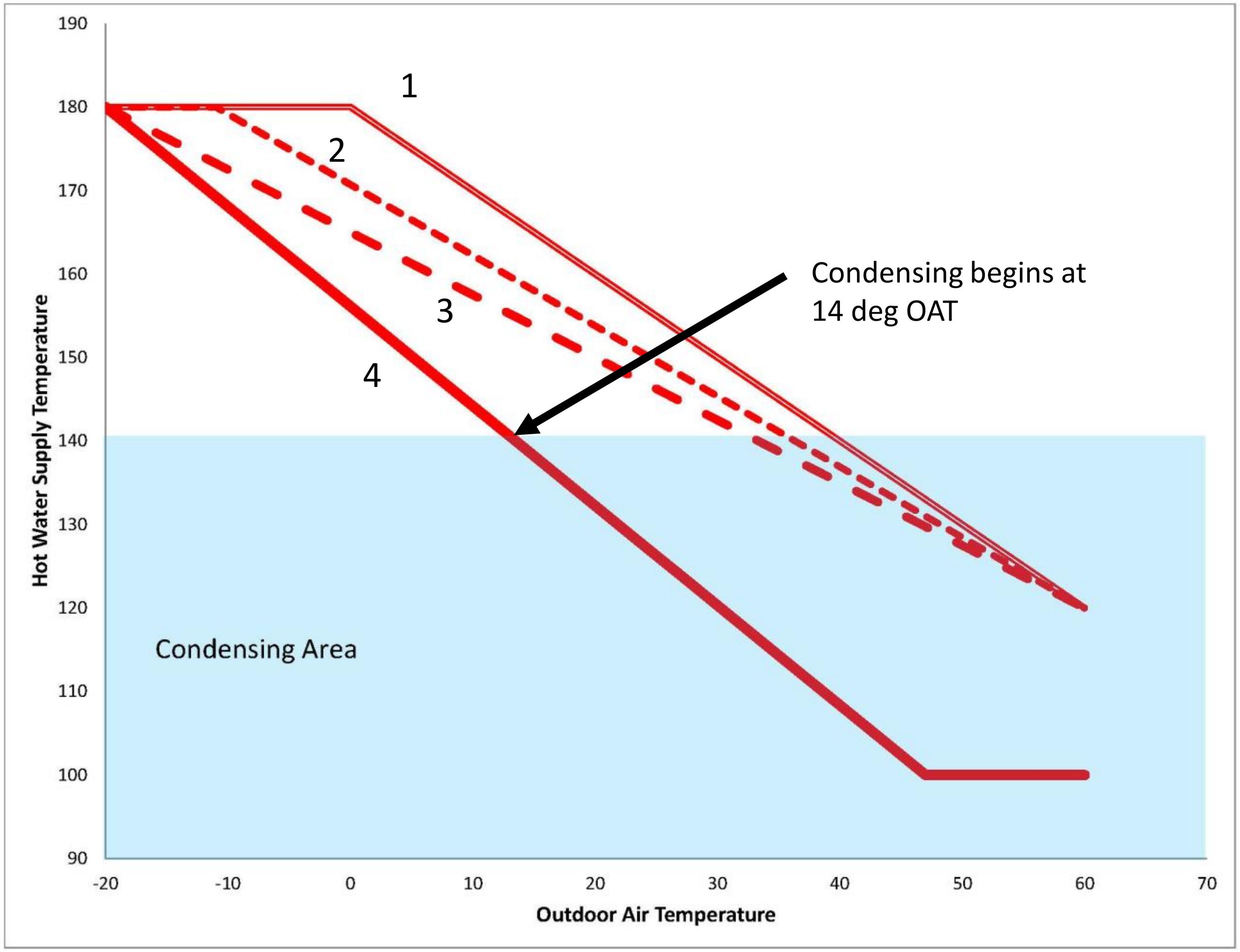
Capacity of finned tube at 90 deg AWT will satisfy the building load at 47 deg OAT.

Determining the Right Reset Schedule

- Lets look at the new reset schedule

OAT		HWST	
OAT_{MIN}	*-20* (0)	$HWST_{MAX}$	180
OAT_{MAX}	*47* (60)	$HWST_{MIN}$	*100* (120)

Determining the Right Reset Schedule



1 – Initial Reset Schedule
2 – MIN OAT from 0 to -11
3 – MIN OAT from -11 to -20
4 – MIN HWST revised, MAX OAT matched.

Determining the Right Reset Schedule

- This revised reset schedule results in condensing operation **93%** of the heating hours in Burlington VT.

OAT		HWST	
OAT_{MIN}	*-20*	$HWST_{MAX}$	180
OAT_{MAX}	*47*	$HWST_{MIN}$	*100*

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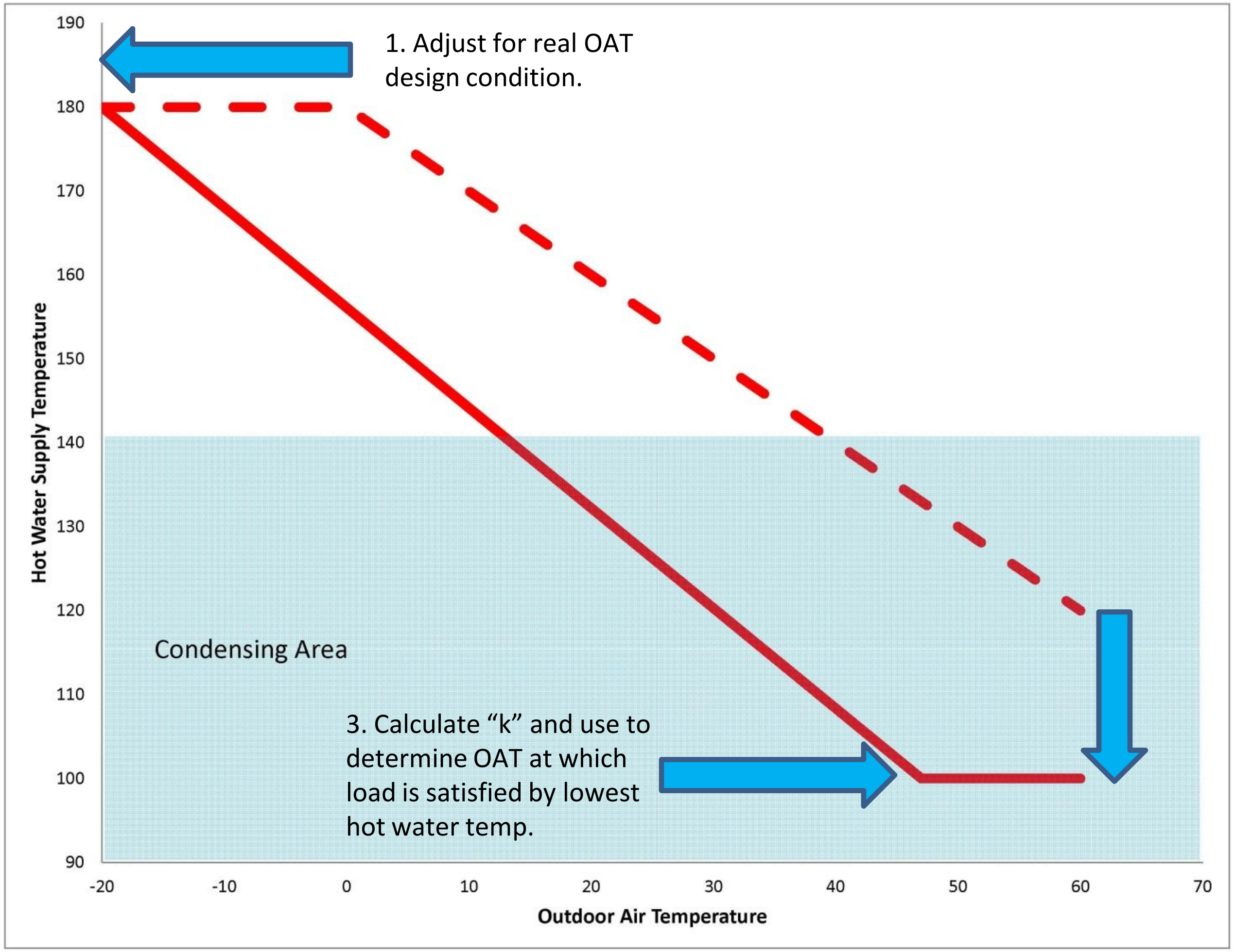
Determining the Right Reset Schedule Overview



2. Use the lowest possible water temp during the warmest conditions.

Determining the Right Reset Schedule Summary

- No change to boiler or selected finned tube.
- Used simple approach to determine the optimal reset schedule.
- Result:

Determining the Right Reset Schedule Summary

- No change to boiler or selected finned tube.
- No change in MAX HWST
- Used simple approach to determine the optimal reset schedule.
- Result:

Increase in condensing hours from 52% to 93% at **no additional first cost.**

Adjusting an Existing Reset Schedule

- Approach is the same but design conditions and FTR capacity may not be known.
- Use a step wise, iterative process to change the various parameters.

Adjusting an Existing Reset Schedule

- Step 1 – Lower the lowest HWST.
- Step 2 – Lower the MAX OAT 3 to 5 degrees at a time, over a period of days or weeks.
- Step 3 – Lower the MIN OAT using what you know about your building.
  - The last time it was -10 or -15 outside, was your building satisfied?

OAT		HWST	
OAT_{MIN}	*-20*	$HWST_{MAX}$	180
OAT_{MAX}	*47*	$HWST_{MIN}$	*100*

Designing for Optimal Condensing Operation

- Learning Objective #4:
  - Be able to size terminal heating equipment for maximum condensing hours.

Fin-Tube Selection

Q_{load} = 6,400 BTUH

Catalog Designation	Steam 215°F Factor 1.00	Hot Water (Avg.)					
		200°F	190°F	180°F	170°F	160°F	150°F
		Factor					
		0.86	0.78	0.69	0.61	0.53	0.45
C3/4-33	10,500	9,000	8,200	7,200	6,400	5,600	4,700

AWT = 130˚F

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Fin-Tube Selection

$Q_{rated} = Q_{215°F} \times CF_{AWT} \times CF_{w\_flow} \times Cf_{height}$

Where:

$Q_{215°F}$ = Catalog capacity

CF_{AWT} = Correction factor for average water temperature

CF_{w_flow} = Correction factor for water flow rate

Cf_{height} = Correction fact for mounting height

AVERAGE WATER TEMP. °F	ENTERING AIR TEMPERATURE, °F														
	45	55	STD 65	70	75	80	85	90	95	100	110	120	130	140	150
90	.19	.13	.11	.06											
100	.25	.19	.15	.11	.08	.06									
110	.31	.25	.20	.16	.13	.11	.08	.60							
120	.38	.31	.26	.21	.19	.16	.13	.11	.08	.06					
130	.45	.38	.33	.28	.25	.21	.19	.16	.13	.11	.06				
140	.53	.45	.40	.34	.31	.28	.25	.21	.19	.16	.11	.06			
150	.61	.53	.45	.41	.38	.34	.31	.28	.25	.21	.16	.11	.06		
160	.69	.61	.53	.49	.45	.41	.38	.34	.31	.28	.21	.16	.11	.06	
170	.77	.69	.61	.57	.53	.49	.45	.41	.38	.34	.28	.21	.16	.11	.06
180	.86	.77	.69	.65	.61	.57	.53	.49	.45	.41	.34	.28	.21	.16	.11
190	.95	.86	.78	.73	.69	.65	.61	.57	.53	.49	.41	.34	.28	.21	.16
200	1.05	.95	.86	.82	.77	.73	.69	.65	.61	.57	.49	.41	.34	.28	.21
210	1.14	1.05	.95	.91	.86	.82	.77	.73	.69	.65	.57	.49	.41	.34	.28
215 (STD.)	1.19	1.09	1.00	.95	.91	.86	.82	.77	.73	.69	.61	.53	.45	.38	.31
220	1.24	1.14	1.05	1.00	.95	.91	.86	.82	.77	.73	.65	.57	.49	.41	.34
230	1.34	1.24	1.14	1.09	1.05	1.00	.95	.91	.86	.82	.73	.65	.57	.49	.41
240	1.44	1.34	1.25	1.19	1.14	1.09	1.05	1.00	.95	.91	.82	.73	.65	.57	.49
250	1.55	1.44	1.34	1.29	1.24	1.19	1.14	1.09	1.05	1.00	.91	.82	.73	.65	.57
260	1.66	1.55	1.44	1.39	1.34	1.29	1.24	1.19	1.14	1.09	1.00	.91	.82	.73	.65
270	1.76	1.66	1.55	1.50	1.44	1.39	1.34	1.29	1.24	1.19	1.09	1.00	.91	.82	.73
280	1.87	1.76	1.66	1.60	1.55	1.50	1.44	1.39	1.34	1.29	1.19	1.09	1.00	.91	.82
290	1.99	1.87	1.76	1.71	1.66	1.60	1.55	1.50	1.44	1.39	1.29	1.19	1.09	1.00	.91
300	2.10	1.99	1.87	1.82	1.76	1.71	1.66	1.60	1.55	1.50	1.39	1.29	1.19	1.09	1.00

AVERAGE WATER TEMP. °F	ENTERING AIR TEMPERATURE, °F														
	45	55	STD 65	70	75	80	85	90	95	100	110	120	130	140	150
90	.19	.13	.11	.06											
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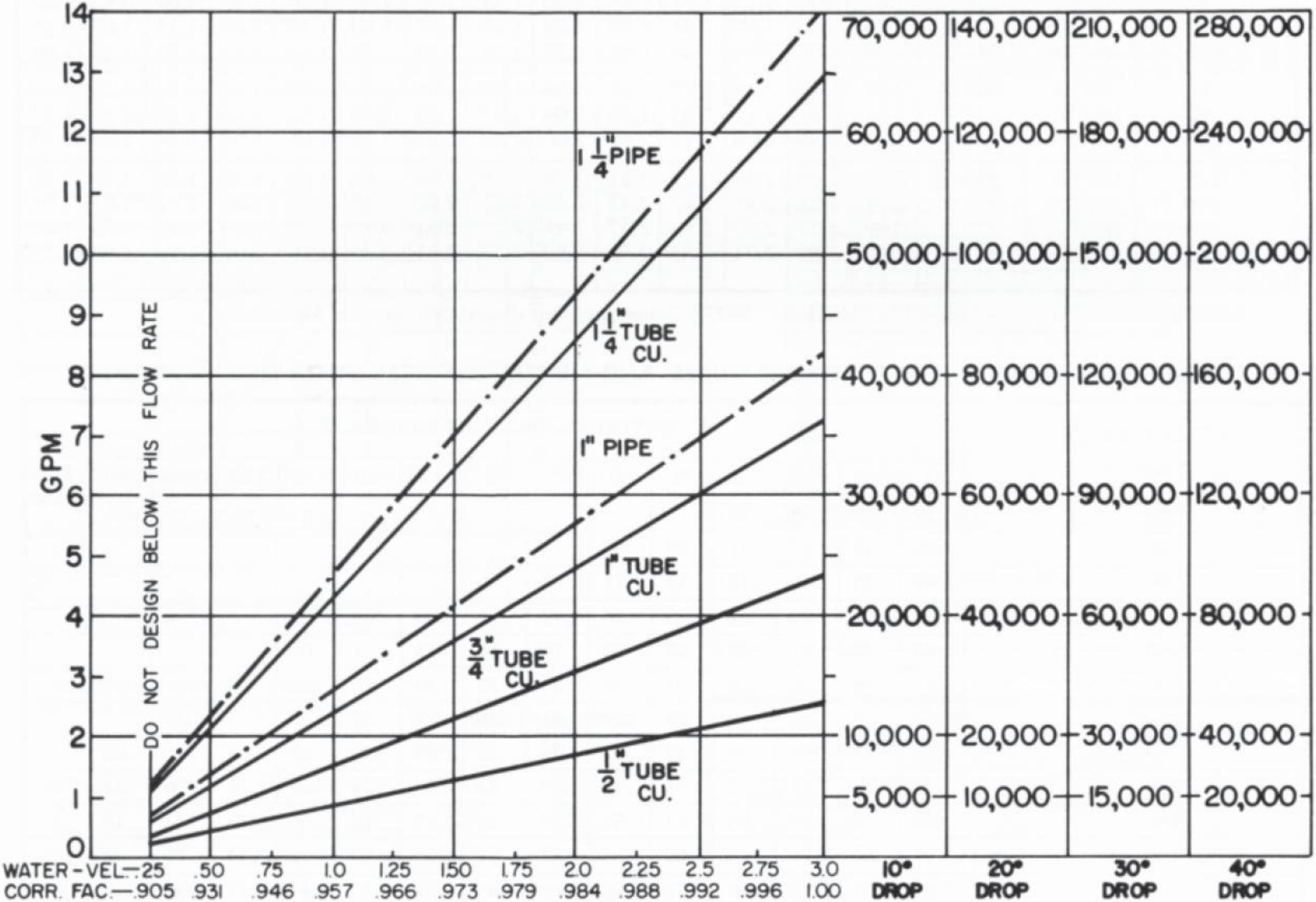
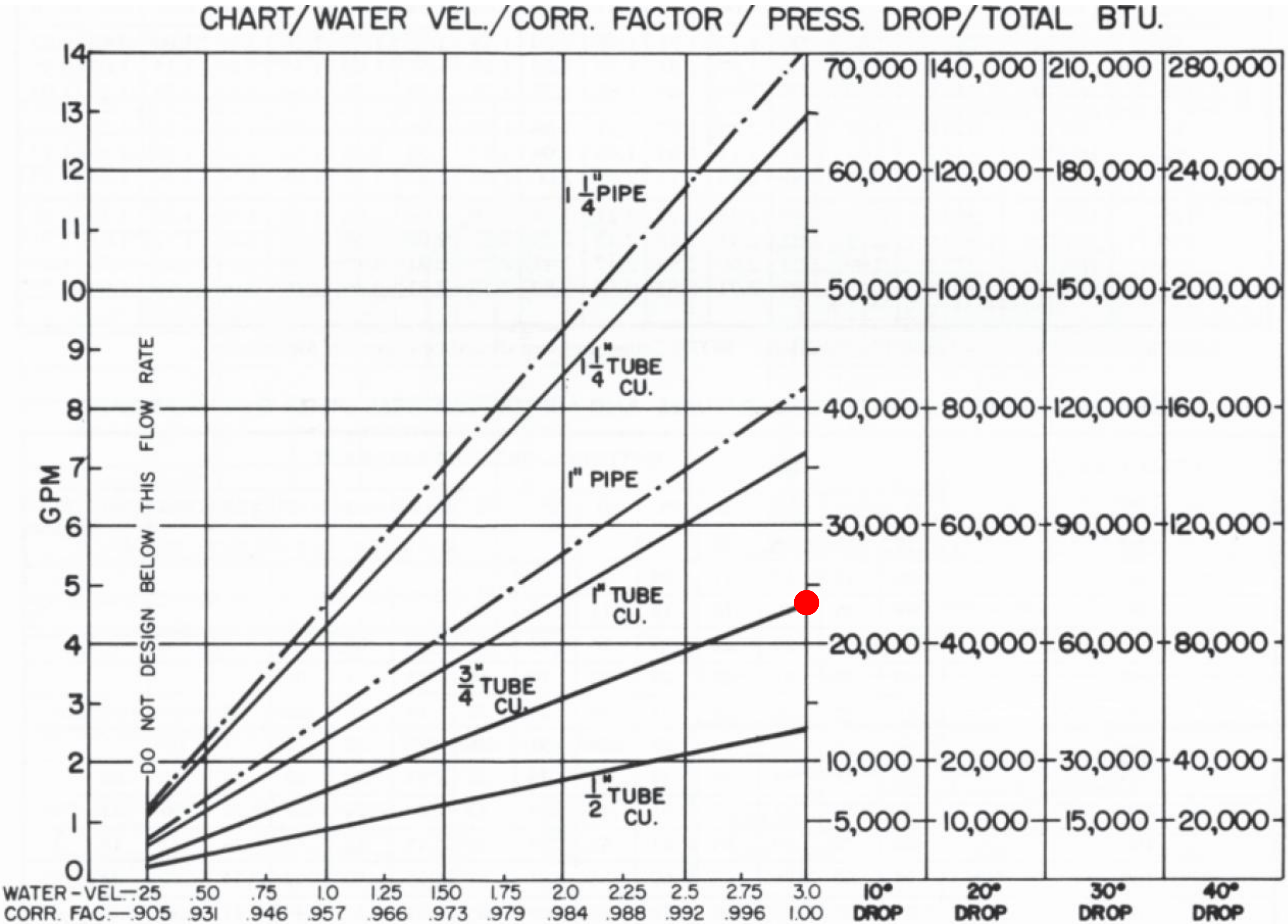
Fin-Tube Selection

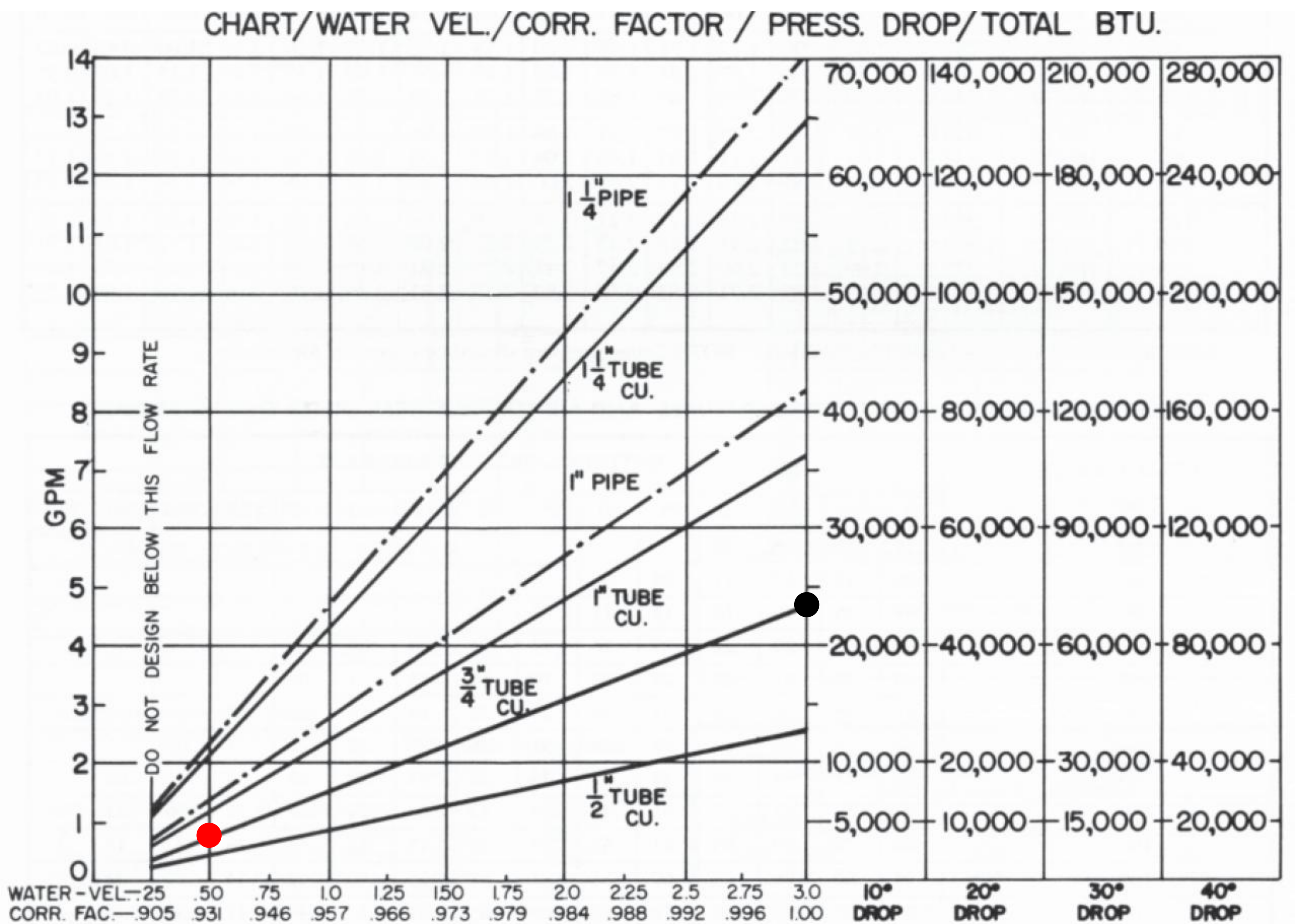
$$Q_{rated} = Q_{215°F} \text{ x } CF_{AWT\_EAT} \text{ x } CF_{w\_flow} \text{ x } Cf_{height}$$

$$Q_{rated} = (10{,}500 \text{ BTUH}) \text{ x } (0.33) \text{ x } CF_{w\_flow} \text{ x } Cf_{height}$$

CHART/WATER VEL./CORR. FACTOR / PRESS. DROP/TOTAL BTU.




CHART/WATER VEL./CORR. FACTOR / PRESS. DROP/TOTAL BTU.
GPM
DO NOT DESIGN BELOW THIS FLOW RATE
1 1/4" PIPE
1 1/4" TUBE CU.
1" PIPE
1" TUBE CU.
3/4" TUBE CU.
1/2" TUBE CU.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
WATER-VEL.—.25 .50 .75 1.0 1.25 1.50 1.75 2.0 2.25 2.5 2.75 3.0
CORR. FAC.—.905 .931 .946 .957 .966 .973 .979 .984 .988 .992 .996 1.00
10° DROP
20° DROP
30° DROP
40° DROP
70,000 140,000 210,000 280,000
60,000 120,000 180,000 240,000
50,000 100,000 150,000 200,000
40,000 80,000 120,000 160,000
30,000 60,000 90,000 120,000
20,000 40,000 60,000 80,000
10,000 20,000 30,000 40,000
5,000 10,000 15,000 20,000



CHART/WATER VEL./CORR. FACTOR / PRESS. DROP/TOTAL BTU.
GPM
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
DO NOT DESIGN BELOW THIS FLOW RATE
1 1/4" PIPE
1 1/4" TUBE CU.
1" PIPE
1" TUBE CU.
3/4" TUBE CU.
1/2" TUBE CU.
70,000
140,000
210,000
280,000
60,000
120,000
180,000
240,000
50,000
100,000
150,000
200,000
40,000
80,000
120,000
160,000
30,000
60,000
90,000
120,000
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5,000
10,000
15,000
20,000
WATER-VEL.—.25 .50 .75 1.0 1.25 1.50 1.75 2.0 2.25 2.5 2.75 3.0
CORR. FAC.—.905 .931 .946 .957 .966 .973 .979 .984 .988 .992 .996 1.00
10° DROP
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Fin-Tube Selection

$Q_{rated} = Q_{215°F} \times CF_{AWT\_EAT} \times CF_{w\_flow} \times Cf_{height}$

$Q_{rated} = (10{,}500 \text{ BTUH}) \times (0.33) \times (0.931) \times Cf_{height}$

Fin-Tube Selection

Q_{rated} = (10,500 BTUH) x (0.33) x (0.931)

Q_{rated} = 3,226 BTUH

Fin-Tube Selection

Q_{load} = 6,400 BTUH

Q_{rated} = 3,226 BTUH (130˚F AWT, 10 ft of fin-tube)

Catalog Designation		Steam 215°F Factor 1.00	Hot Water (Avg.)					
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C3/4-33	BTUH	10,500	9,000	8,200	7,200	6,400	5,600	4,700

- Need twice the amount of fin-tube!

Fin-Tube Selection

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C3/4-33	BTUH	10,500	9,000	8,200	7,200	6,400	5,600	4,700

- Need twice the amount of fin-tube!
- Gain only 510 additional hours of condensing operation.

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Indirect DHW

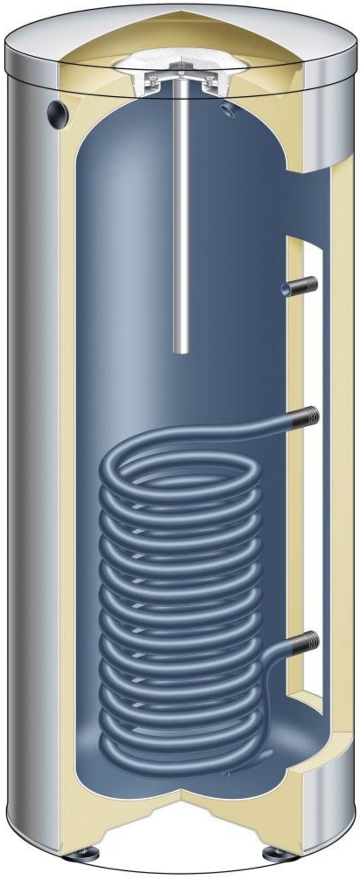
- Learning Objective #5:
  - Describe operation of indirect DHW
  - Relate boiler HW temperature back to efficiency
  - Describe non-heating season impacts.

The Domestic Hot Water Demon

Cx associates LLC

The Domestic Hot Water Demon

- What is “indirect” DHW?
  - Heat source is used to heat an intermediary medium rather than the DHW itself.



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The Domestic Hot Water Demon

- Physics dictates that the heat source must be hotter than the DHW.
- Most off-the-shelf controllers use 180 deg F source hot water
  - Non-adjustable.
  - Forget about condensing.
  - Need 130 deg return to START condensing.
- BMS Controlled systems have more flexibility.
  - Mostly a trial and error process

The Domestic Hot Water Demon
Non-Heating Season

- Burlington, VT:
  - 1,765 hours where no heating is needed.
  - Optimized reset schedule allows for 8,160 hours of condensing operation.
- BUT – You need DHW all year round.
- When the boiler makes 180 deg water you lose the efficiency gains we just got for free!

The Domestic Hot Water Demon Non-Heating Season

- Boiler short cycling is a known efficiency killer.
  - Patterson Kelly has noted measured reductions of 15% to 40% in efficiency attributable to short cycling.
- Boilers are nearly always sized for the heating load and not the DHW load.
  - This leads to a lot of…

The Domestic Hot Water Demon

Short Cycling

The Domestic Hot Water Demon
What to Do

Separate the heating and DHW equipment.

The Domestic Hot Water Demon
What to Do

Conclusion

- System selection and control setpoints (hot water reset schedule) are key to achieving condensing boiler efficiencies.
  - Keep your return water temperatures as low as you can for as long as you can.
  - Ensure that terminal heating is sized for condensing temperatures.
  - Separate heating boilers and DHW boilers.

Conclusion

- Basic math may be used to estimate optimal hot water reset schedule setpoints.

  $Q = \Delta T \times k$

- Most of the efficiency benefit of condensing boilers may be achieved through optimizing setpoints.
  - $0 capital cost!!!

Questions?

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